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Letab Rest Camp, Oct. 23 2019

Barcelona Supercomputing Center
Centro Nacional de Supercomputación

EXCELENCIA SEVERO OCHOA

# Decadal predictability of wildfires within the ESM EC-Earth


**Etienne Tourigny,**
**BSC Climate Prediction & Computational Earth Sciences groups**
**Lund University**

# Decadal predition of wildfires

- **SPFireSD** : Seasonal Prediction of Fire danger using Statistical and Dynamical models
- MARIE SkŁodowska-CURIE ACTIONS Individual Fellowship (MSCA-IF)
- SPFireSD proposes to develop and assess **seasonal (to decadal) fire prediction capability** through a variety of complementary and innovative methods using statistical and dynamical models, with a focus on Europe, the Amazonian basin and Indonesia.
- This project will develop and assess seasonal prediction capability of wildfire danger using three complementary approaches:
  - 1) **Fire danger indices** approach: simple fire danger indices computed from seasonal dynamical climate prediction systems
  - 2) **Statistical** approach: statistical fire danger models using a combination of past observational data and seasonal dynamical climate forecasts
  - 3) **Dynamical** approach: ensemble dynamical predictions using state-of-the-art fire models within Earth System Models (LPJ-Guess part of the EC-Earth Earth System Model)

# Decadal predition of wildfires

- **The plan** :
  - Use several LPJ-GUESS fire models to predict seasonal-to decadal wildfire risk
  - Test the framework with an offline setup:
    - Use the EC-Earth model to get atmospheric fields
    - Use GlobFIRM in the EC-Earth offline setup
    - Test better fire models (SIMFIRE/BLAZE, SPITFIRE), with the help of external partners (Lund, Senckenberg) – thanks to Stijn for the contacts!
  - Use the model(s) in a fully-coupled EC-Earth ESM setup

# Decadal predition of wildfires

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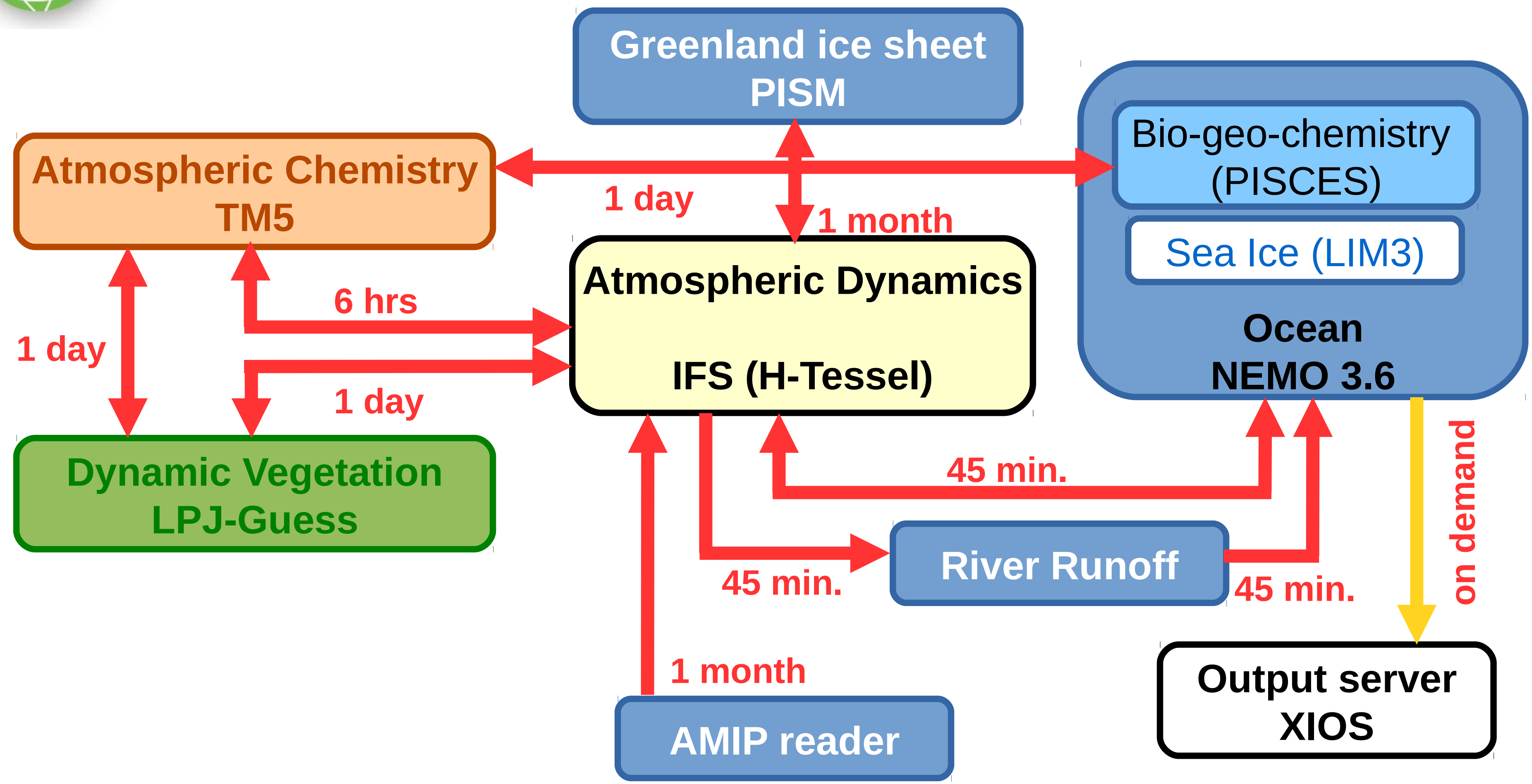
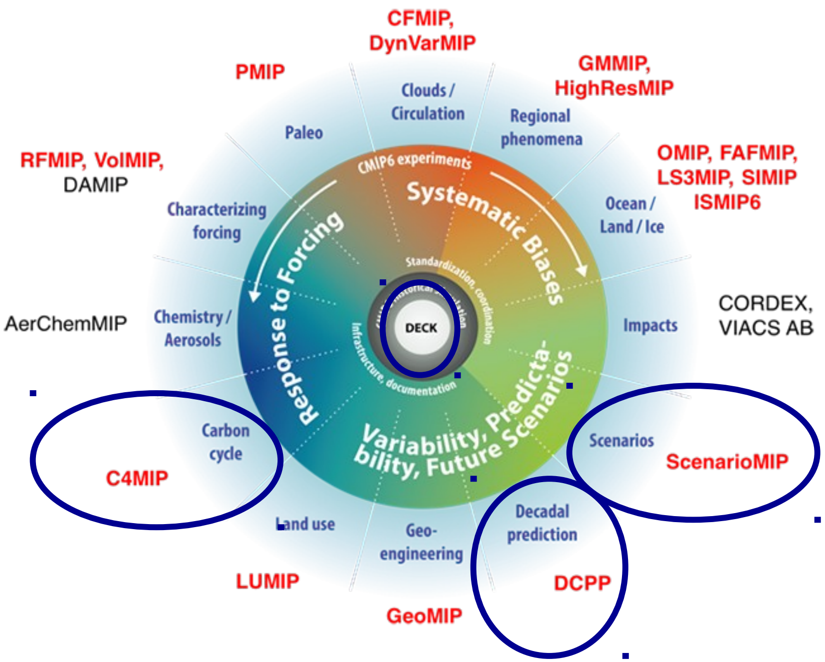
    - Test better fire models (SIMFIRE/BLAZE, SPITFIRE), with the help of external partners (Lund, Senckenberg) – thanks to Stijn for the contacts!
  - Use the model(s) in a fully-coupled EC-Earth ESM setup
- **Reality** :
  - Offline model development took longer than expected
  - Better models are not yet in the EC-Earth LPJ-GUESS version
  - BSC involvement in other projects (CMIP6, C4MIP, CCiCC) has become a priority
  - The current status: offline model using GlobFIRM and CMIP6 DCPP prediction output
  - Future work will hopefully achieve the goal!

# EC-Earth3-CC Earth System Model






WCRP CMIP6
World Climate Research Programme

EUCP
European Climate Prediction system

## Contributions to CMIP6

EC-Earth 3.3.1 in standard resolution (~1°)

**DCPP Component A:**
Retrospective Predictions [1960-2017]

**DCPP Component B:**
Near-real time Forecasts [2018 onwards]

**DECK+ScenarioMIP:**
Historical+SPSS2-4.5 [1850-2100]

**C4MIP**

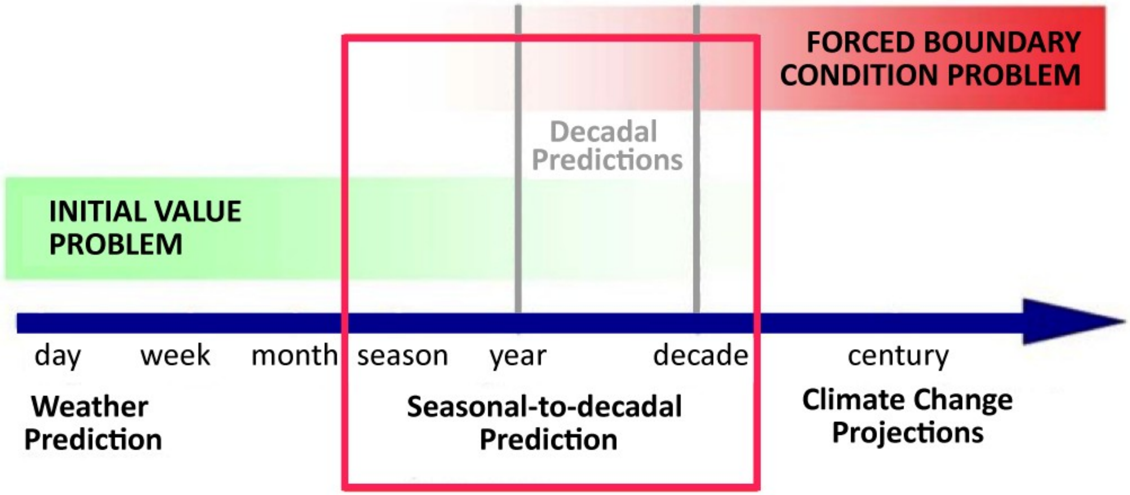
## Other H2020 activities

CCiCC (Carbon-Climate Interactions)

**DCPP Component A-like:**
Retrospective Predictions [1960-2017]

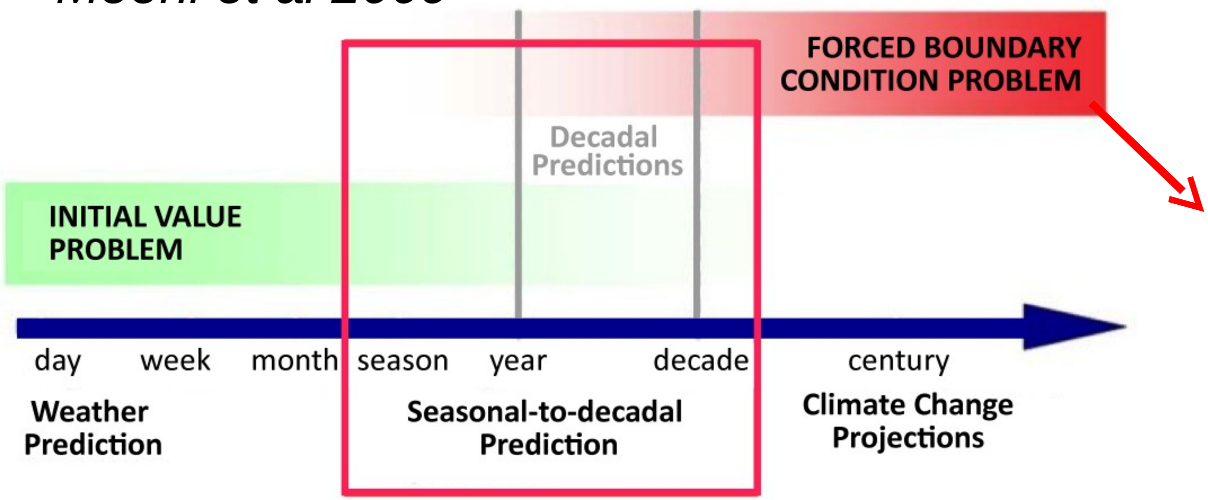
# Cornerstones of climate prediction

*Meehl et al 2009*



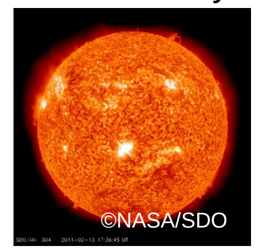
# Cornerstones of climate prediction

*Meehl et al 2009*

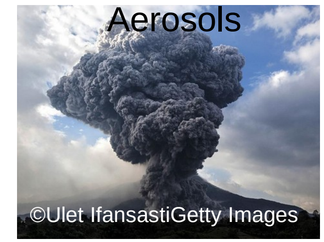



Predictability relying on future changes in the forcing

Solar Activity




Volcanic Aerosols




GHGs

# Cornerstones of climate prediction

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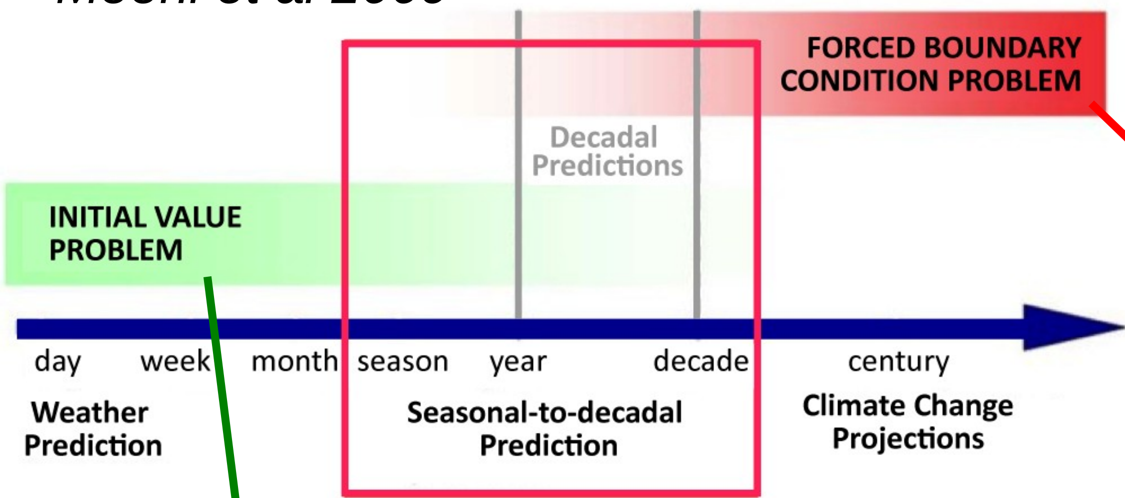
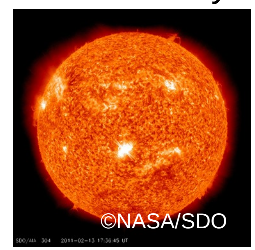


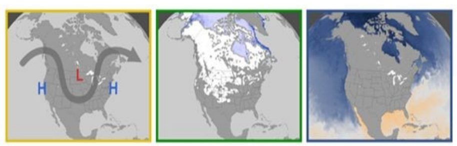

Predictability relying on good guess of future changes in the forcing

Solar Activity

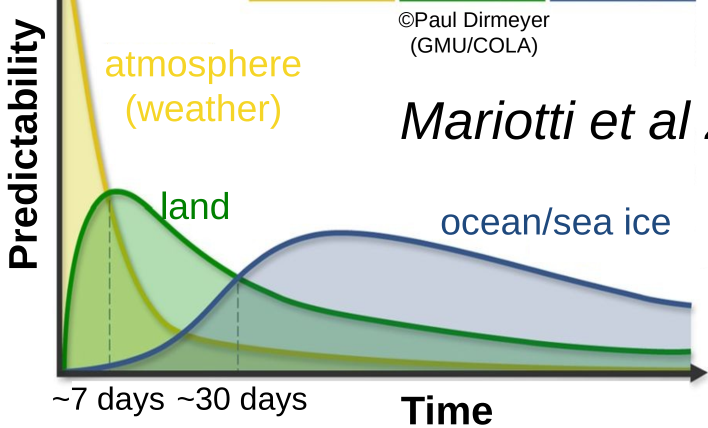



Volcanic Aerosols


GHGs

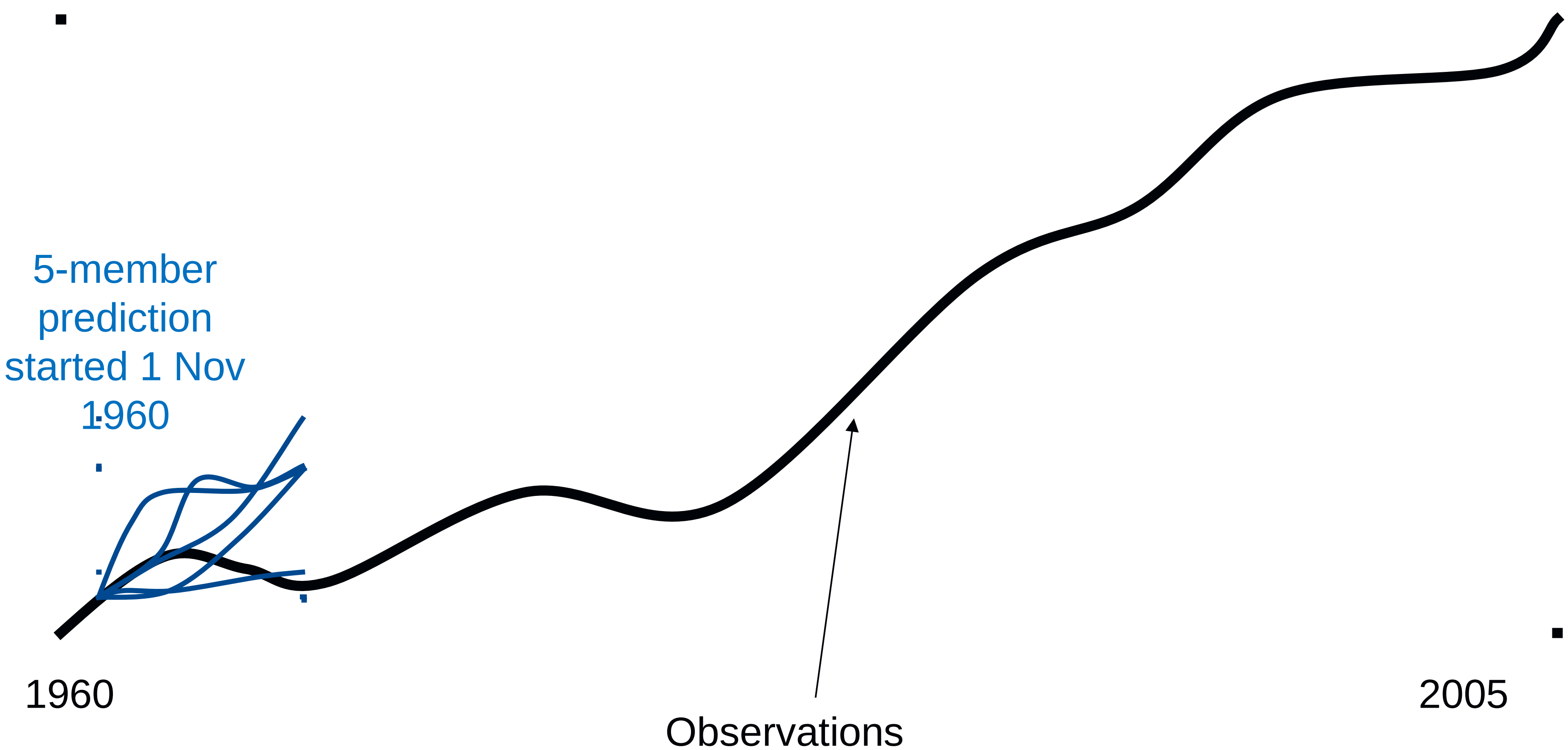

©Paul Dirmeyer (GMU/COLA)



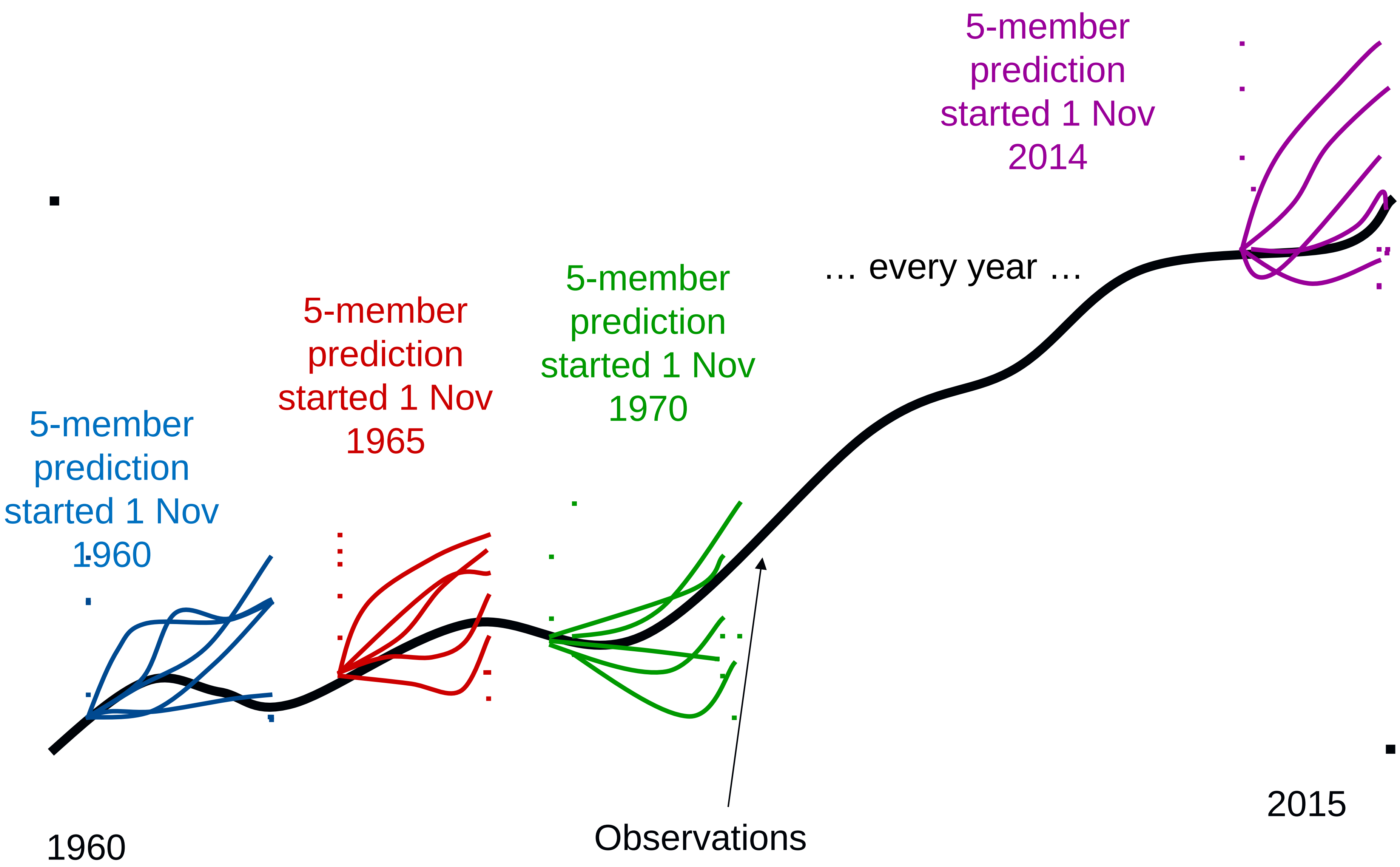

*Mariotti et al 2018*

Predictability arising from the memory of slow processes/components in the climate system

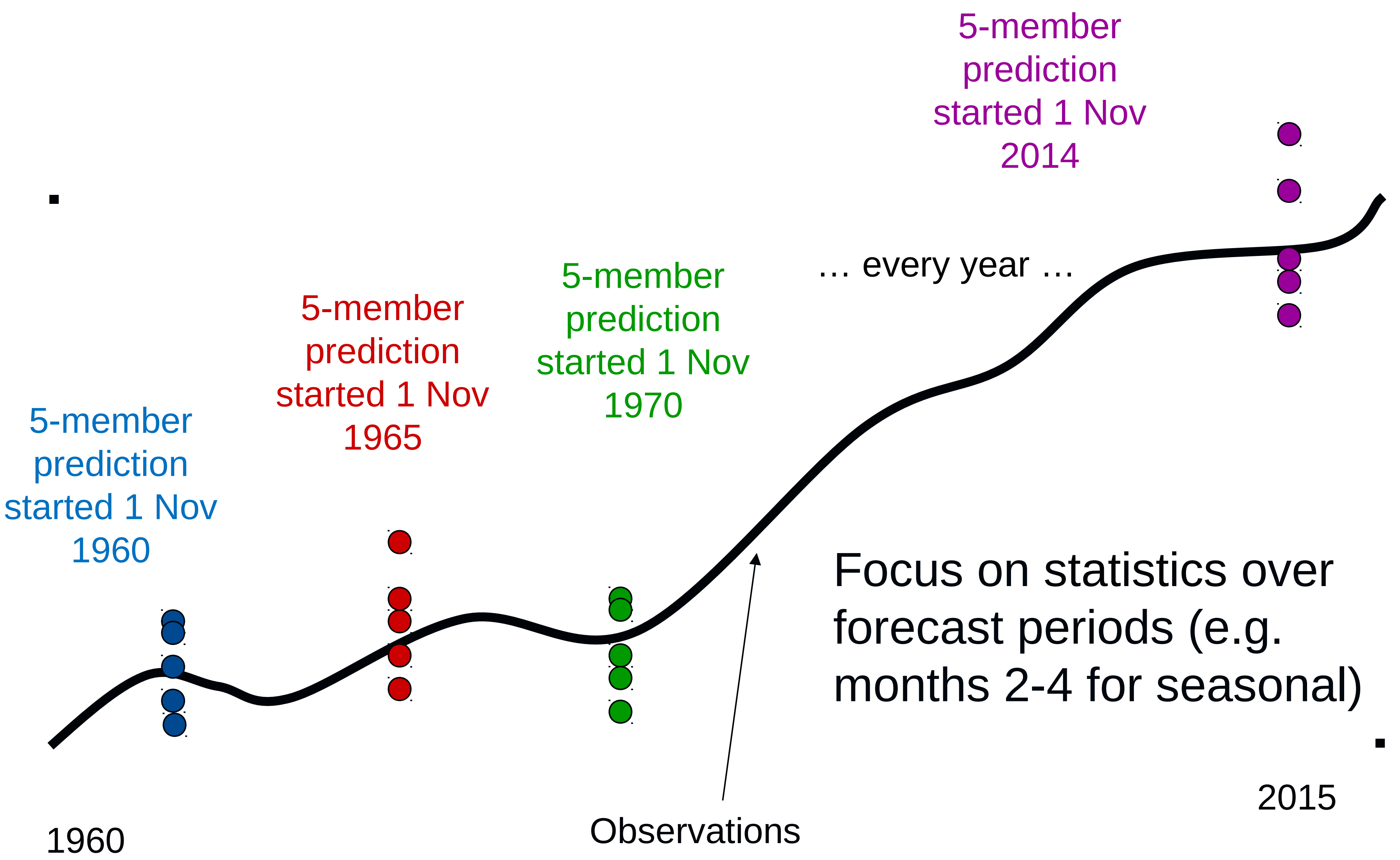
# Climate prediction experiments



# Climate prediction experiments



# Climate prediction experiments




Focus on statistics over forecast periods (e.g. months 2-4 for seasonal)

# Initial Conditions

**ATM**:
Interpolated to model grid with OpenIFS (now performed locally at BSC)

Atmosphere reanalysis (**ERA 40 + Interim**)

Land reanalysis (**ERA-Land**)

Ocean reanalysis (**ORAS4**)

Sea Ice reanalysis

Produced at BSC

**LAND:**
Offline land-surface simulation with near-surface meteorology and corrected fluxes from ERA-Interim

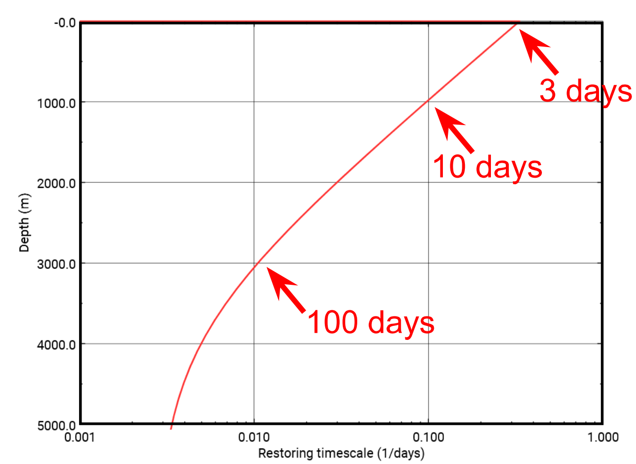
**OCE+ SI**:
Historical reconstruction with NEMO-LIM stand alone, forced with ERA-40/Interim fluxes, and nudged globally towards 3D T and S from ORAS4

*Default surface restoring coefficients*

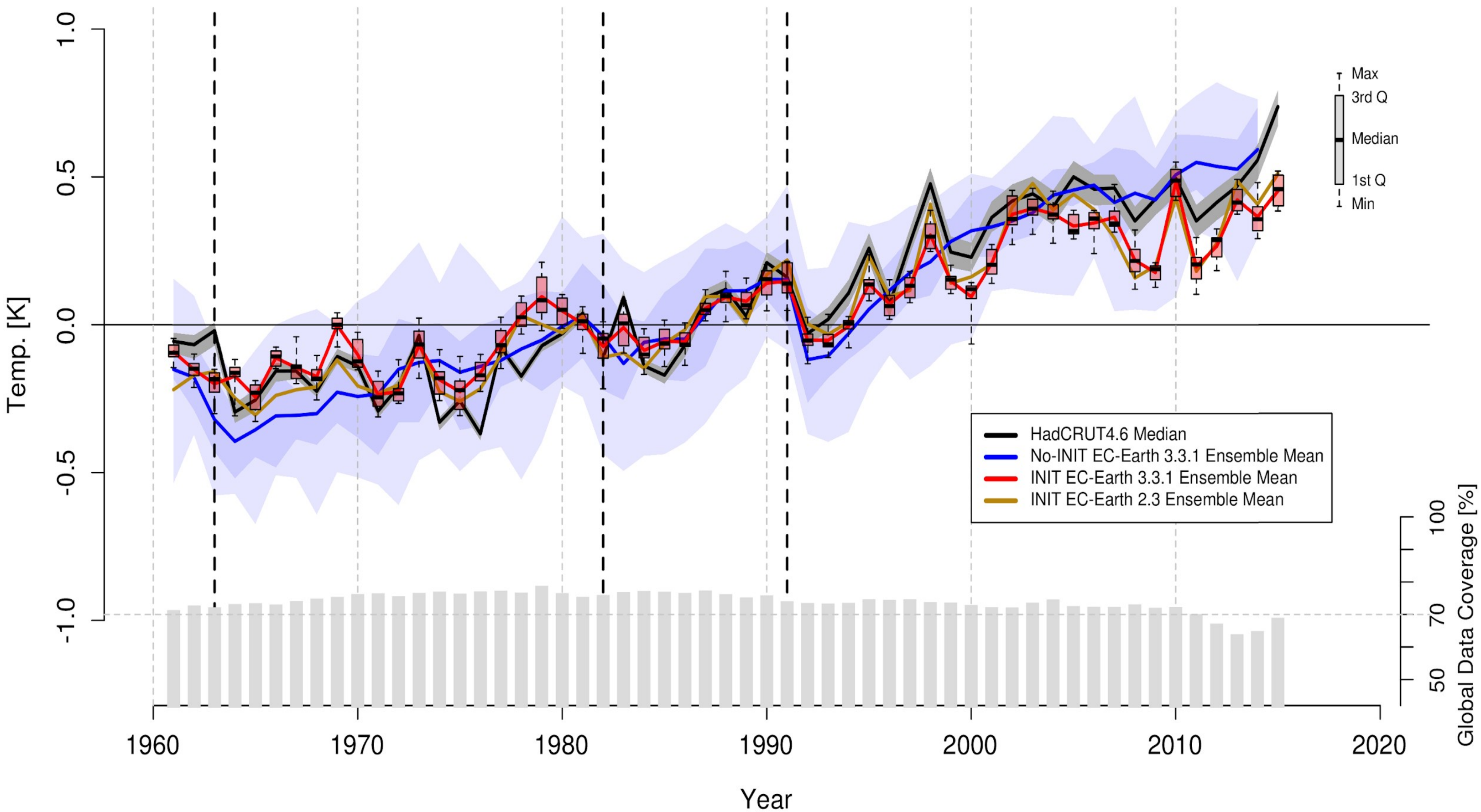
$\gamma_T$ = **-40W/m²/K**

$\gamma_S$ = **-150 kg/m2/s/psu**

*Default 3D restoring timescales*



Forecast Year 1 (M3-14)
Combination of 2m temperature over land and SST over ocean



# Future Carbon – Climate interactions

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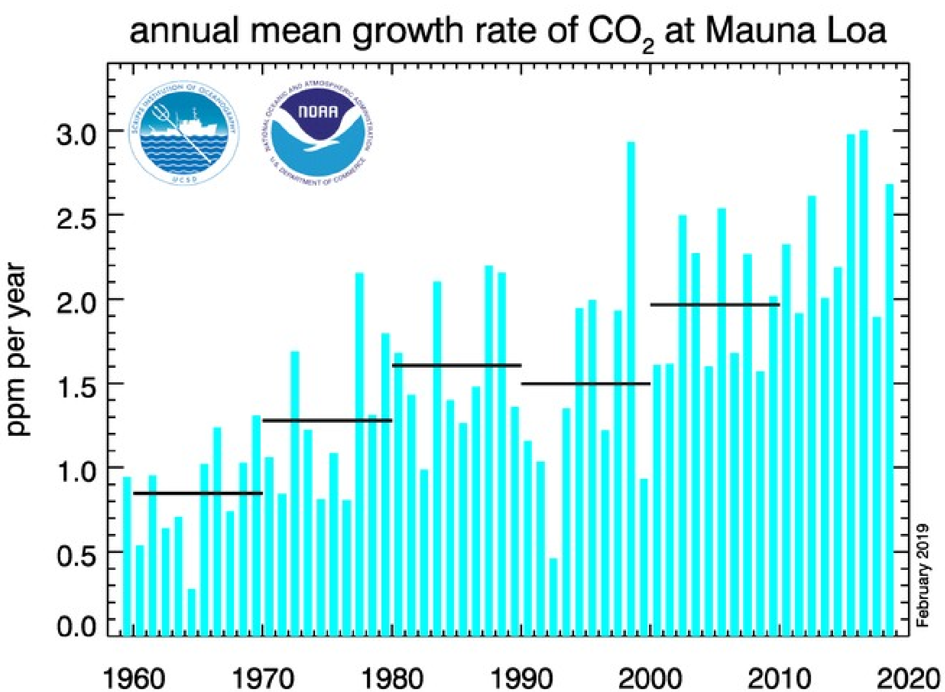
## CCiCC


**Towards a near-term prediction of the climate and carbon cycle interactions in response to Paris Agreement emission trajectories**

Variability in atm CO2 growth rate is mostly due to natural variability

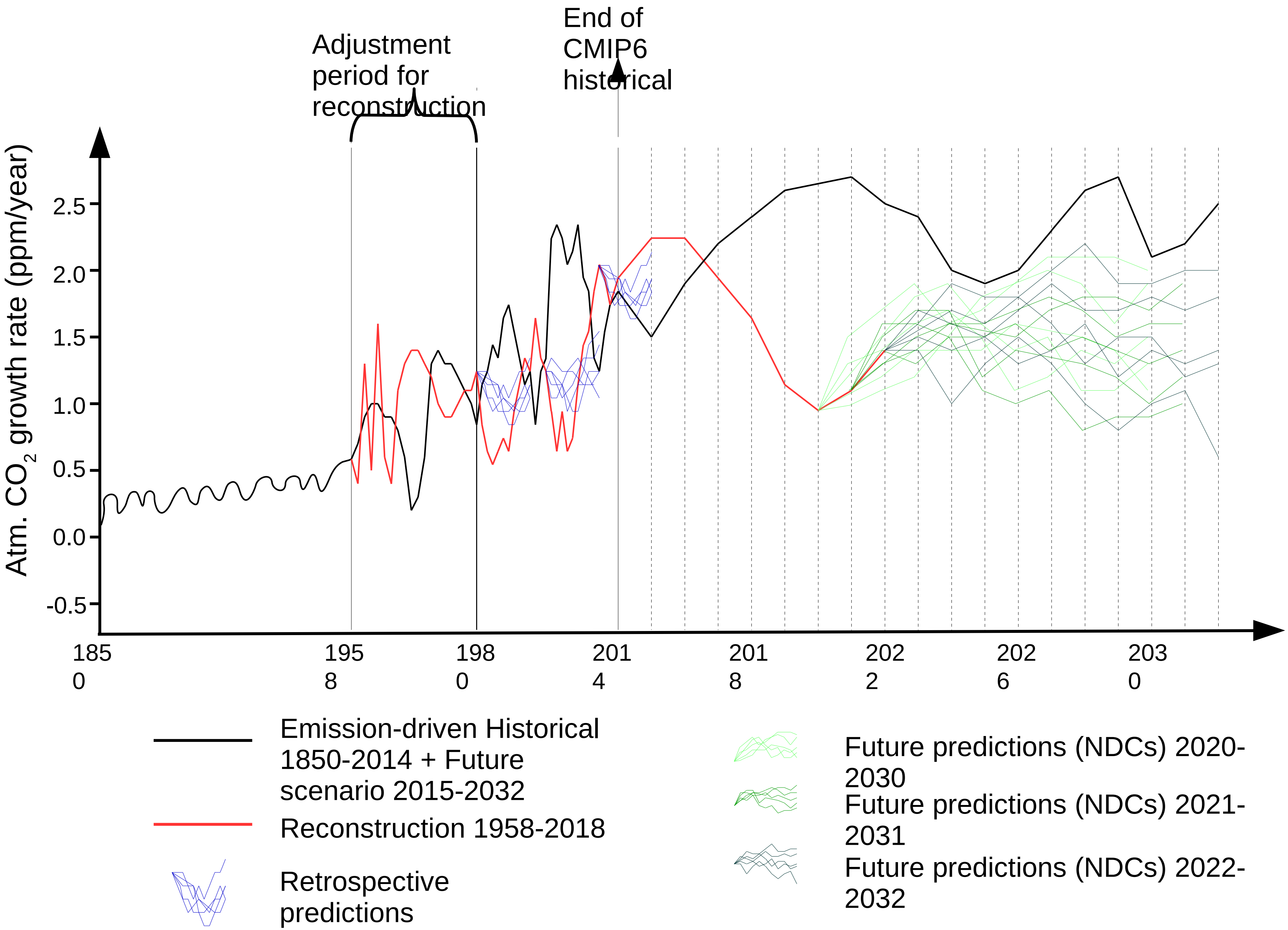



Testing different ocean biogeochemical reconstructions as initial conditions

Retrospective decadal predictions of ocean and land carbon uptake

Idealized perfect-model experiments to investigate mechanisms of C uptake predictability in the ocean.

# Future Carbon – Climate interactions

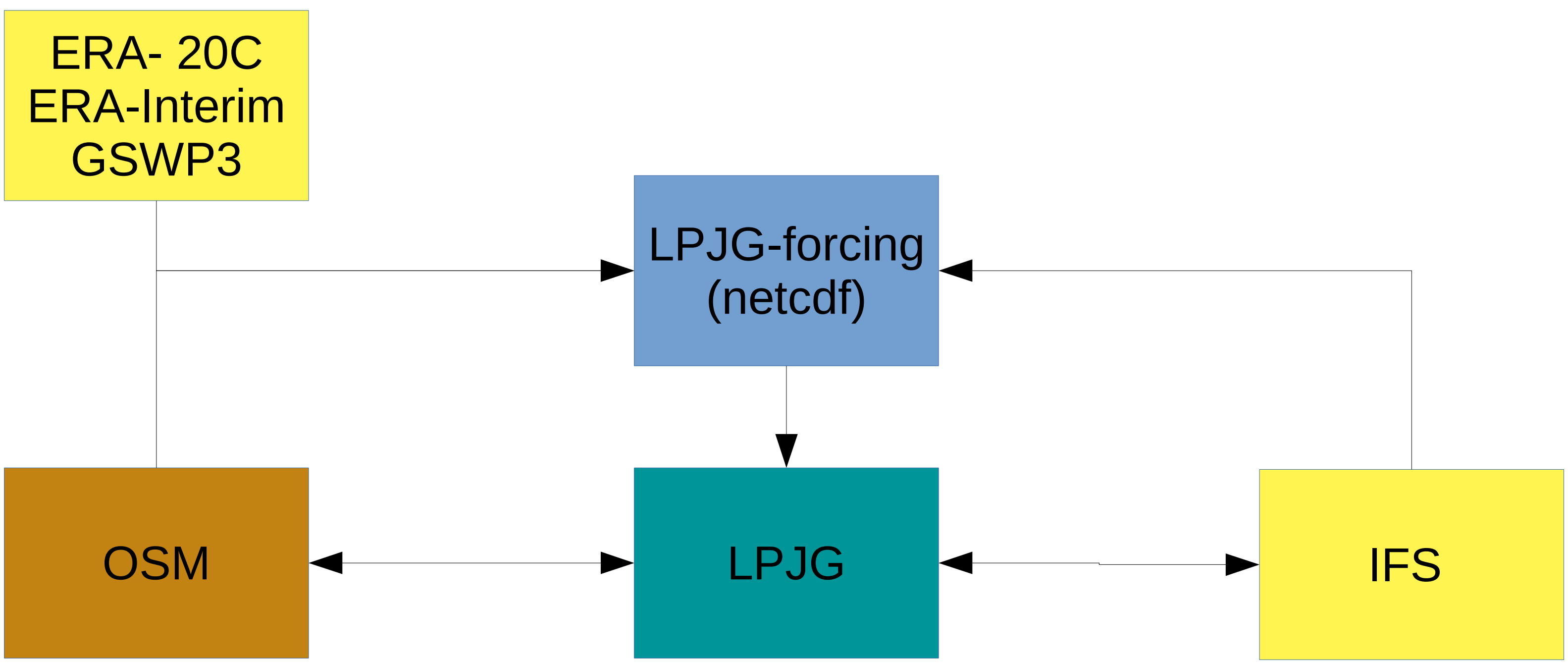


# Offline LSM status

**LSM (Land Surface Model)** contains 3 components:

- **LPJG**, as used in the ESM configuration
- **LPJG-forcing** (aka Sparring), used to send atmospheric forcings to LPJG
- **OSM** (Offline Surface Model), offline version of the IFS surface model (H-TESSEL)

**Forcings** can be either From Reanalyses or IFS output



# Offline LSM status

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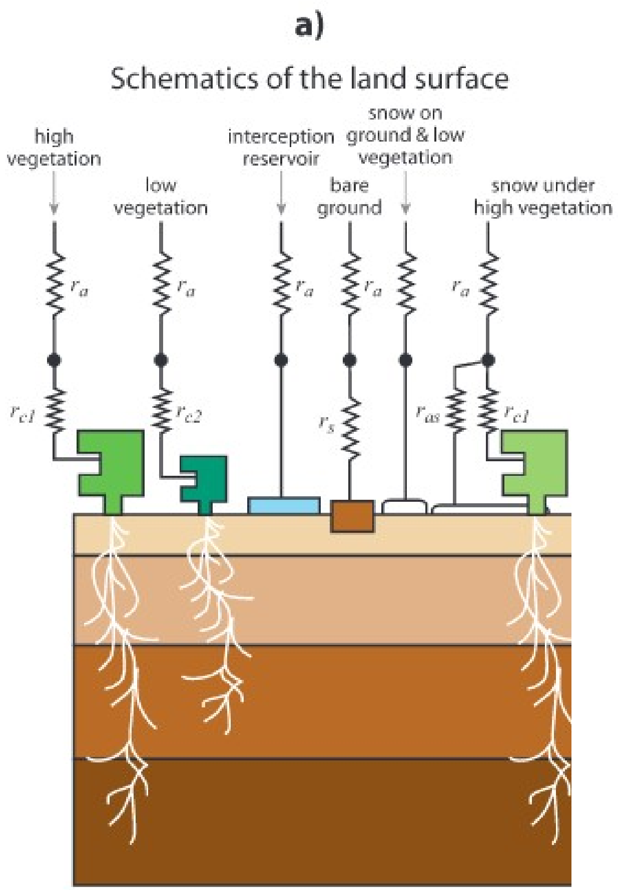
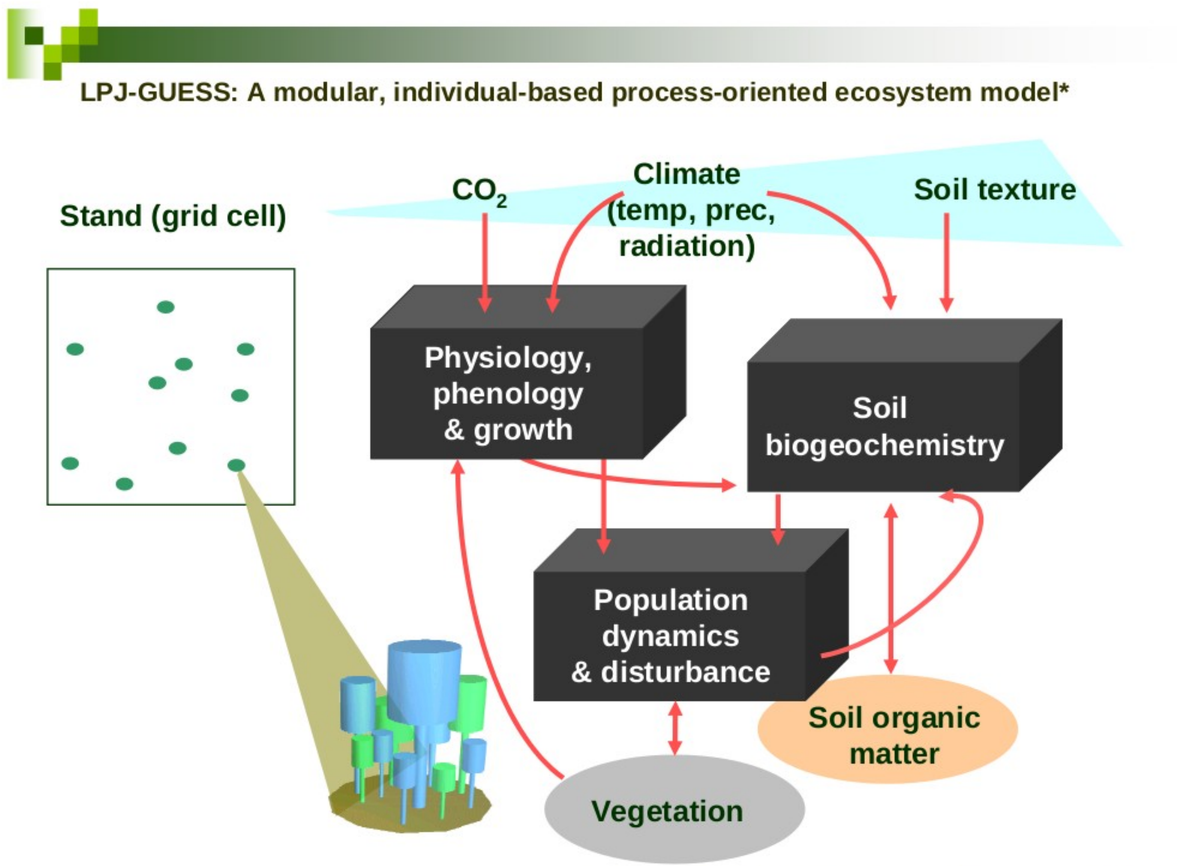
- Uses of the EC-Earth offline LSM
  - Easy generation of Spinup / piControl / historical runs forced by reanalyses
  - Forcings from ERA20C / ERA-Interim / ERA5 / GSWP3
  - Can be used to generated ERA-Land initial conditions for IFS, using the same land model
  - Use in CMIP6 (LS3MIP, LUMIP & DCPP) & CCiCC
- Contributions to LPJ-GUESS
  - Compressed output of text files – much faster offline runs, used by Paul Miller for GSWP3
  - Testing and improvement of fire models (SIMFIRE/BLAZE, SPITFIRE) in the EC-Earth framework
  - Development of “full” restarts in the middle of the year

# LSM : H-TESSEL + LPJ-GUESS



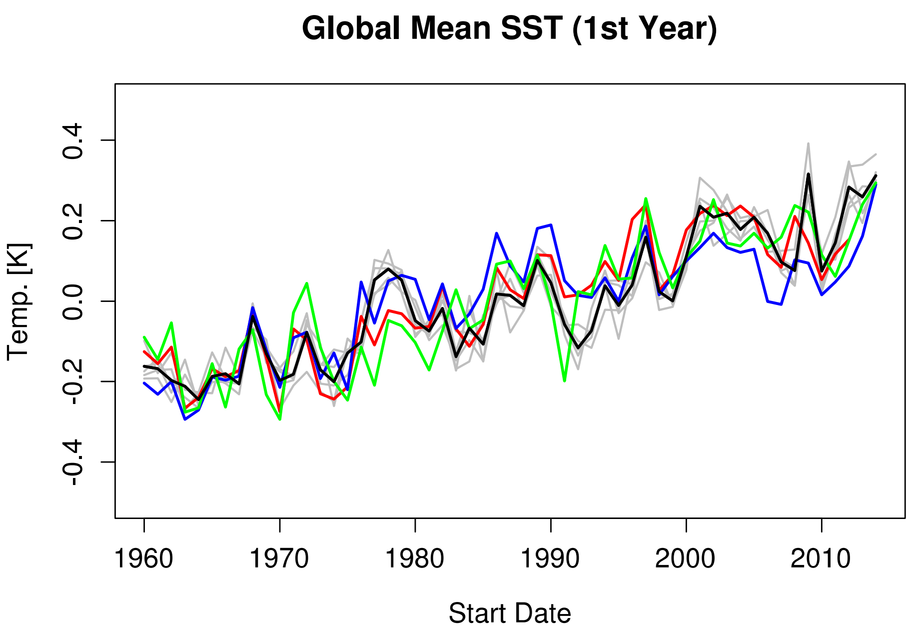


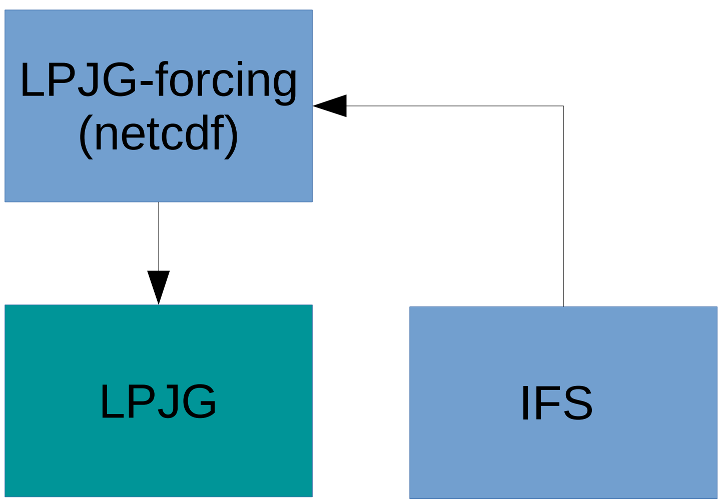




*Smith et al. 2001 *Global Ecology and Biogeography* 10: 621

# Climate prediction experiments

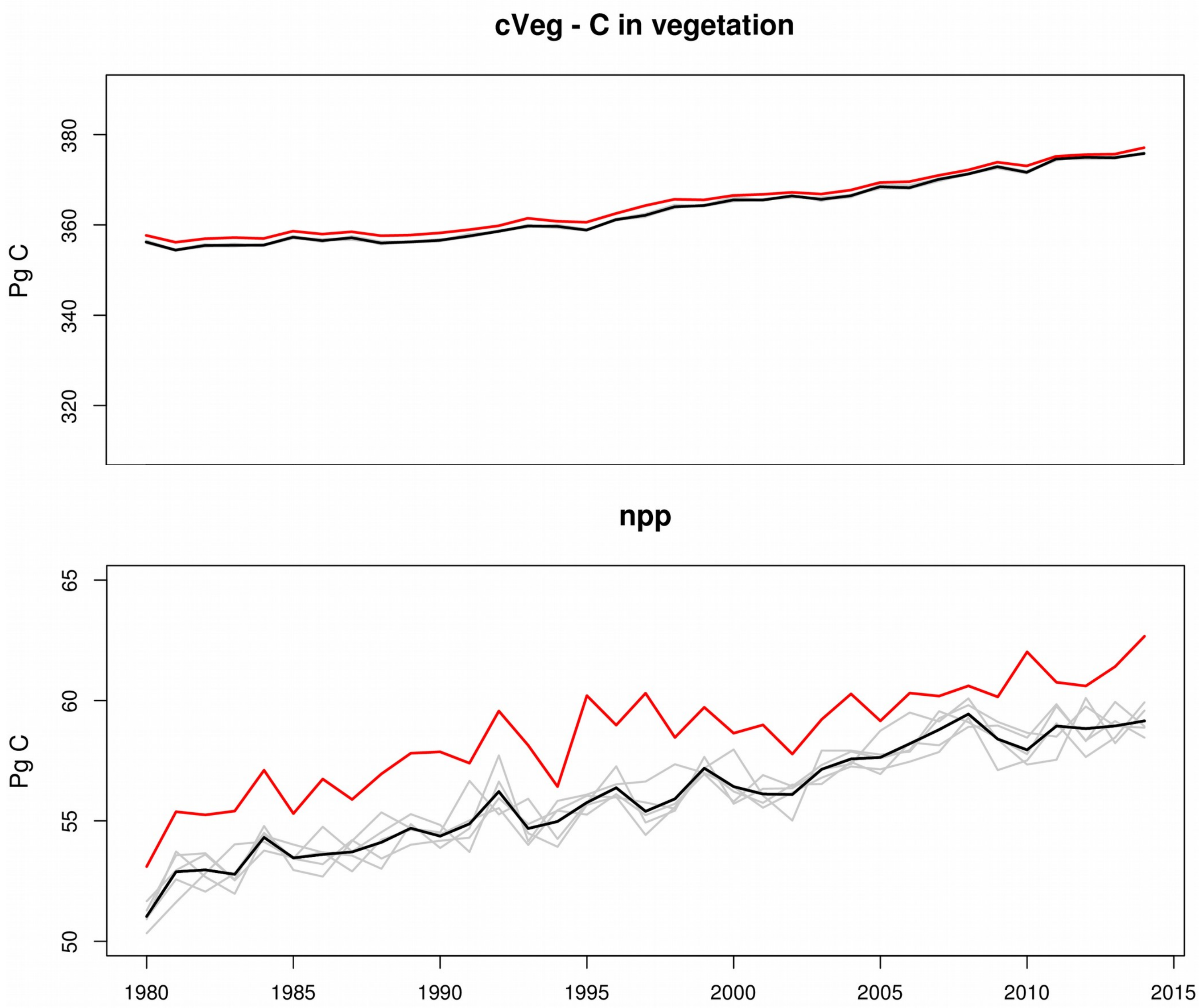
- DCPP LPJG-offline experiment :
  - **LPJG initial states** from ERA-Interim forced offline run
  - Daily output from BSC's DCPP hindcasts (1960-2015), 5 years, 5 members
  - Allows to test the fire model before doing fully-coupled decadal hindcasts of the carbon cycle (CCiCC)



# 1st year DCPP vs ERA-Interim

LPJG initial states from offline run **forced by ERA-Interim reanalysis**, NPP is lower than ERA-Interim forced offline run



# 1st year DCPP vs ERA-Interim

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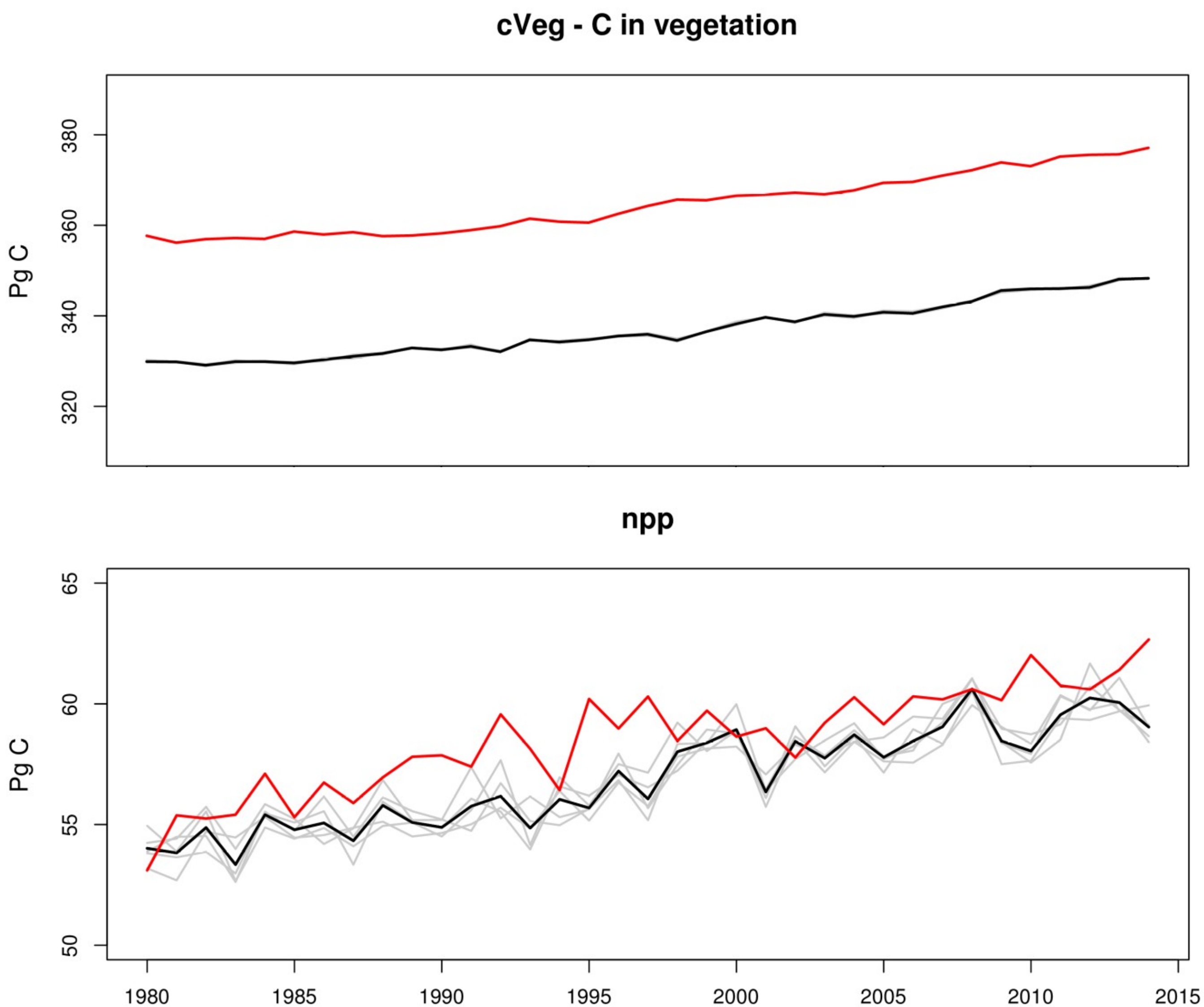
LPJG initial states from **EC-Earth historical run**,
Initialized with less vegetation Carbon than ERA-Interim forced offline run



# State of the art Wildfire models

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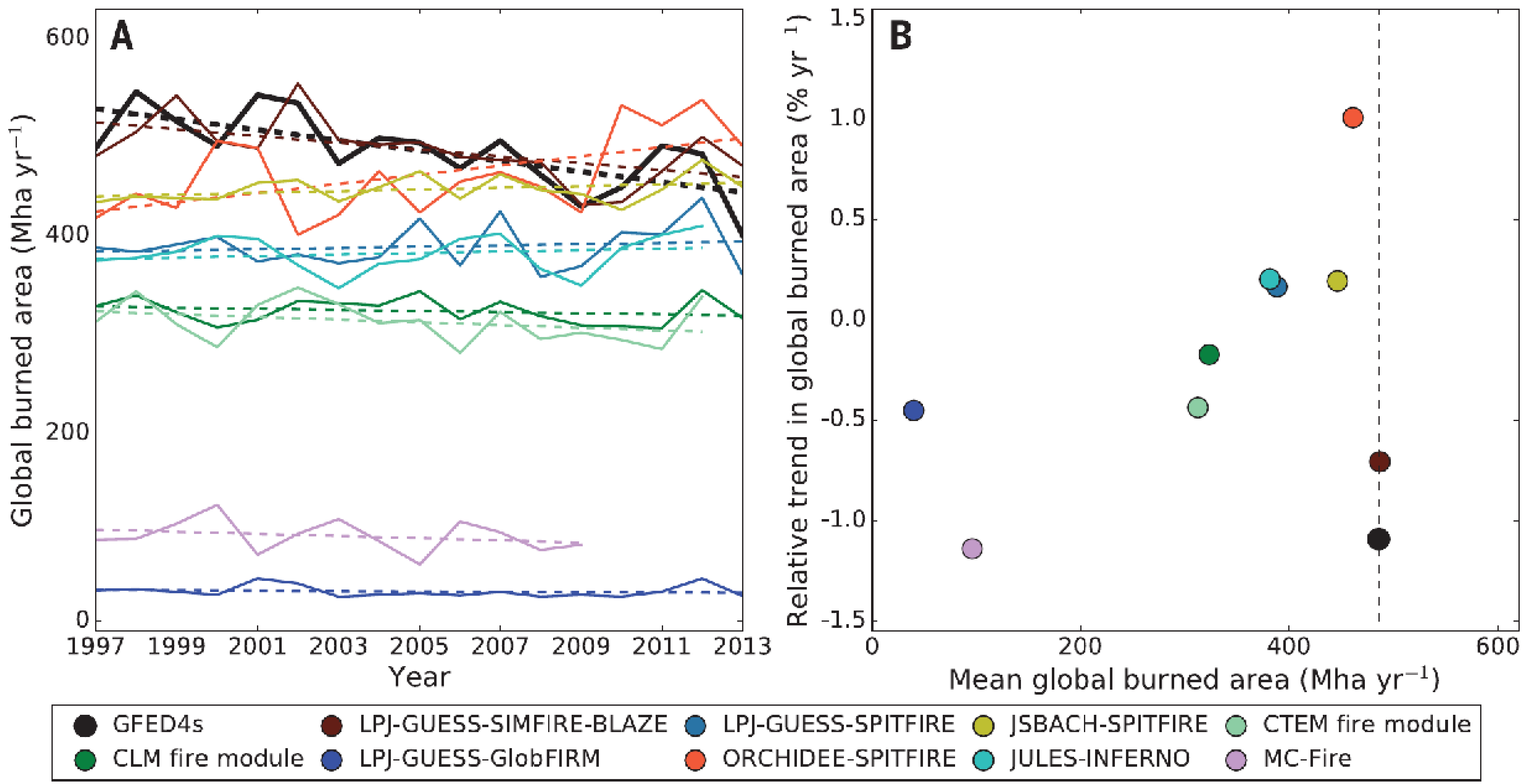
Comparison of burned area simulated by several offline fire models (FIREMIP)

Current model in LPJG is the worst – GlobFIRM
The best is SIMFIRE-BLAZE – soon in our LPJG version!

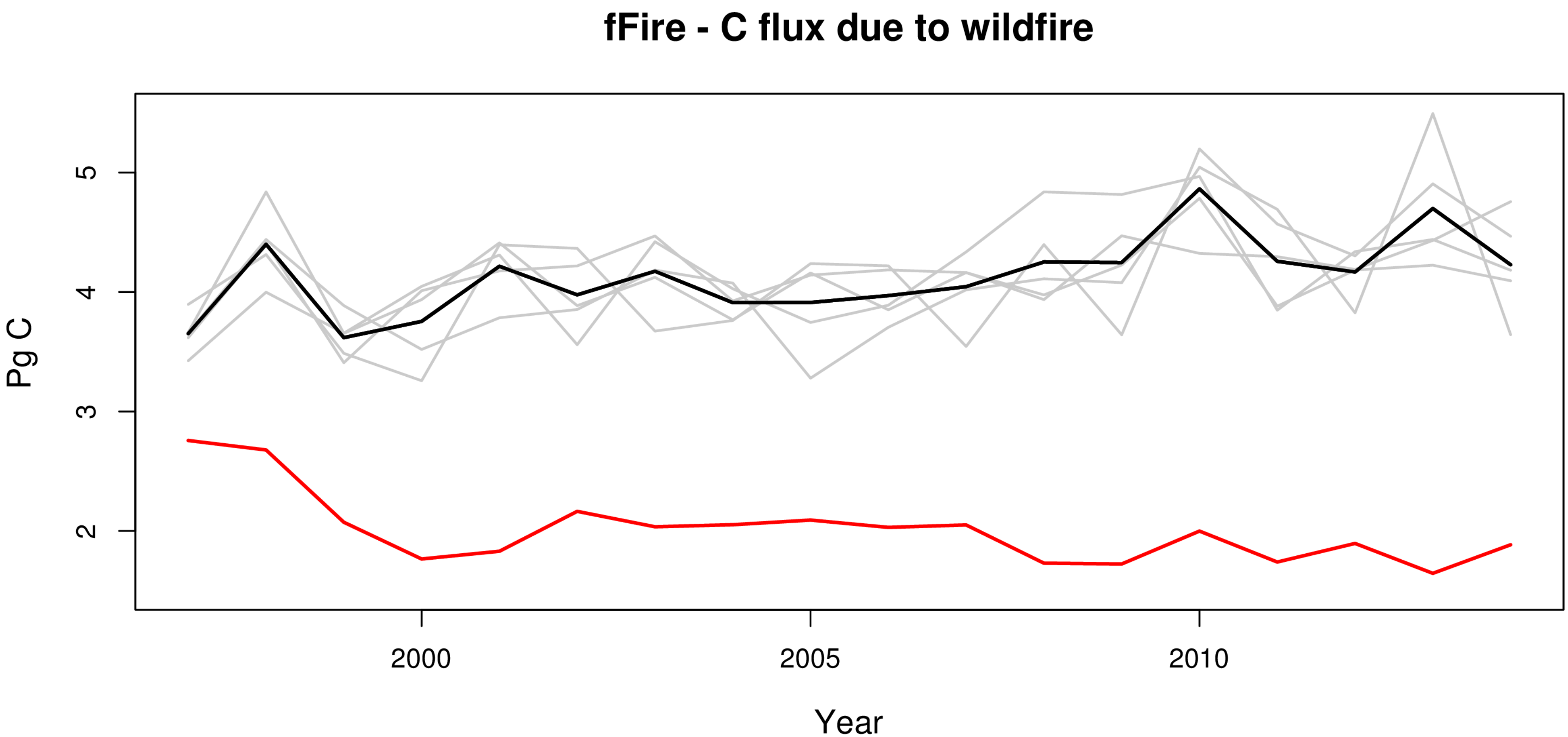


# 1st year DCPP vs. GFED emissions

Fluxes from the GlobFIRM fire model are higher than GFED emissions,
Despite lower burned area (not shown).

Large variability among ensemble members.

Hope is that better fire models (SIMFIRE/BLAZE, SPITFIRE) will perform better.

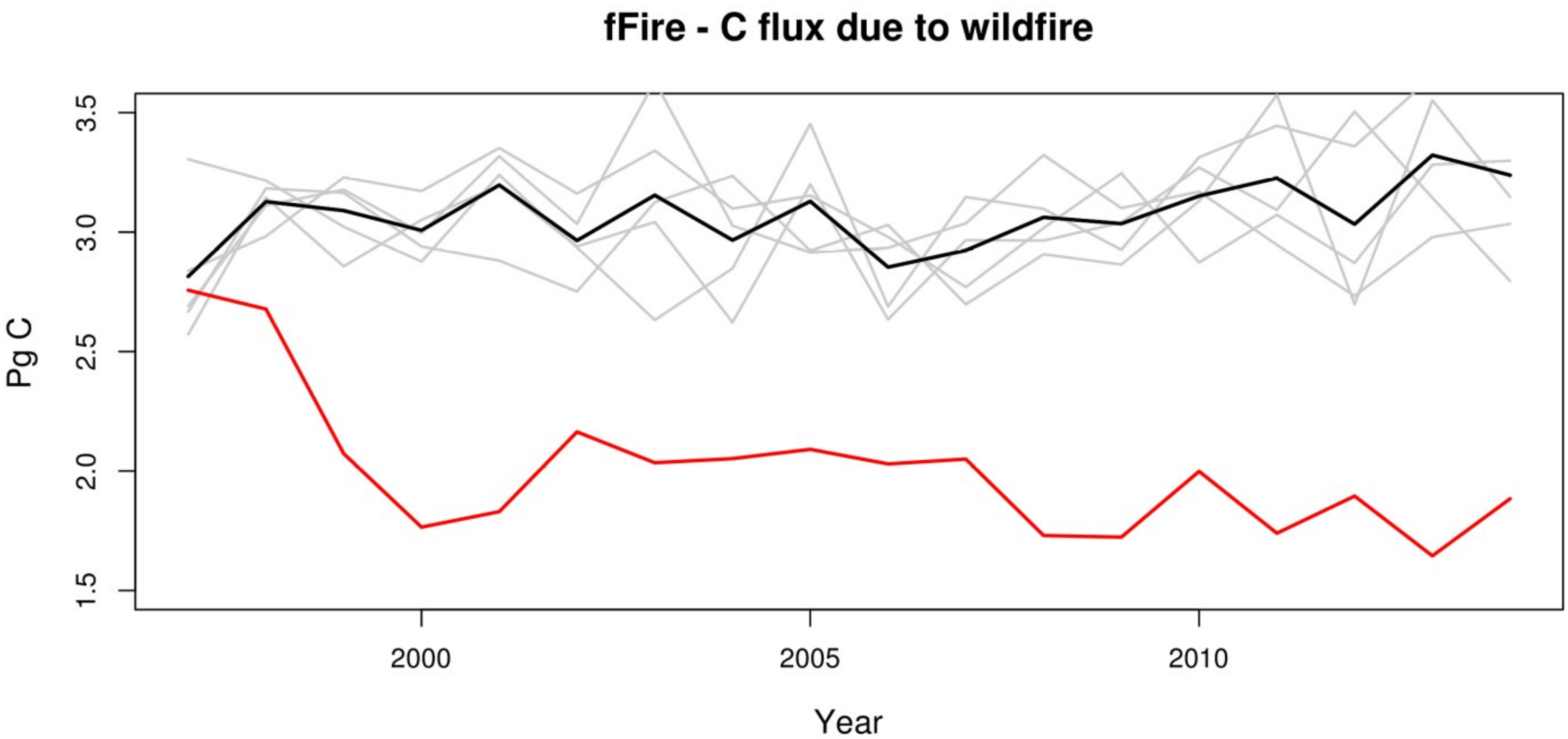


# 1st year DCPP vs. GFED emissions

When LPJG is initialized from EC-Earth coupled runs, fluxes are lower

Because there is less biomass in the first place?

Working on comparing the 2 setups.



# Decadal predition of wildfires

- **Summary** :
  - Implemented offline setup to :
    - Initialize vegetation for decadal predictions of carbon & fire
    - Test (fire) model development
  - Tested on GlobFIRM model – need to validate basic vegetation
  - Not yet used with better fire models (waiting for others)
  - Almost ready to use in a fully-coupled EC-Earth ESM setup for CCiCC
- **Questions** :
  - Interest in decadal prediction in FireMIP in general?
  - Which variables are best suited for validation of initial states & predictions?
  - Where to get validation data at global scales (biomass, GPP, LAI) ?
  - General topic – how to properly initialize the model states used for the predictions? Assimilation/comparing to observed biomass?

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# Thank you!

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MARIE CURIE ACTIONS

This project has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement No 748750 "SPFireSD" - Seasonal Prediction of Fire danger using Statistical and Dynamical models